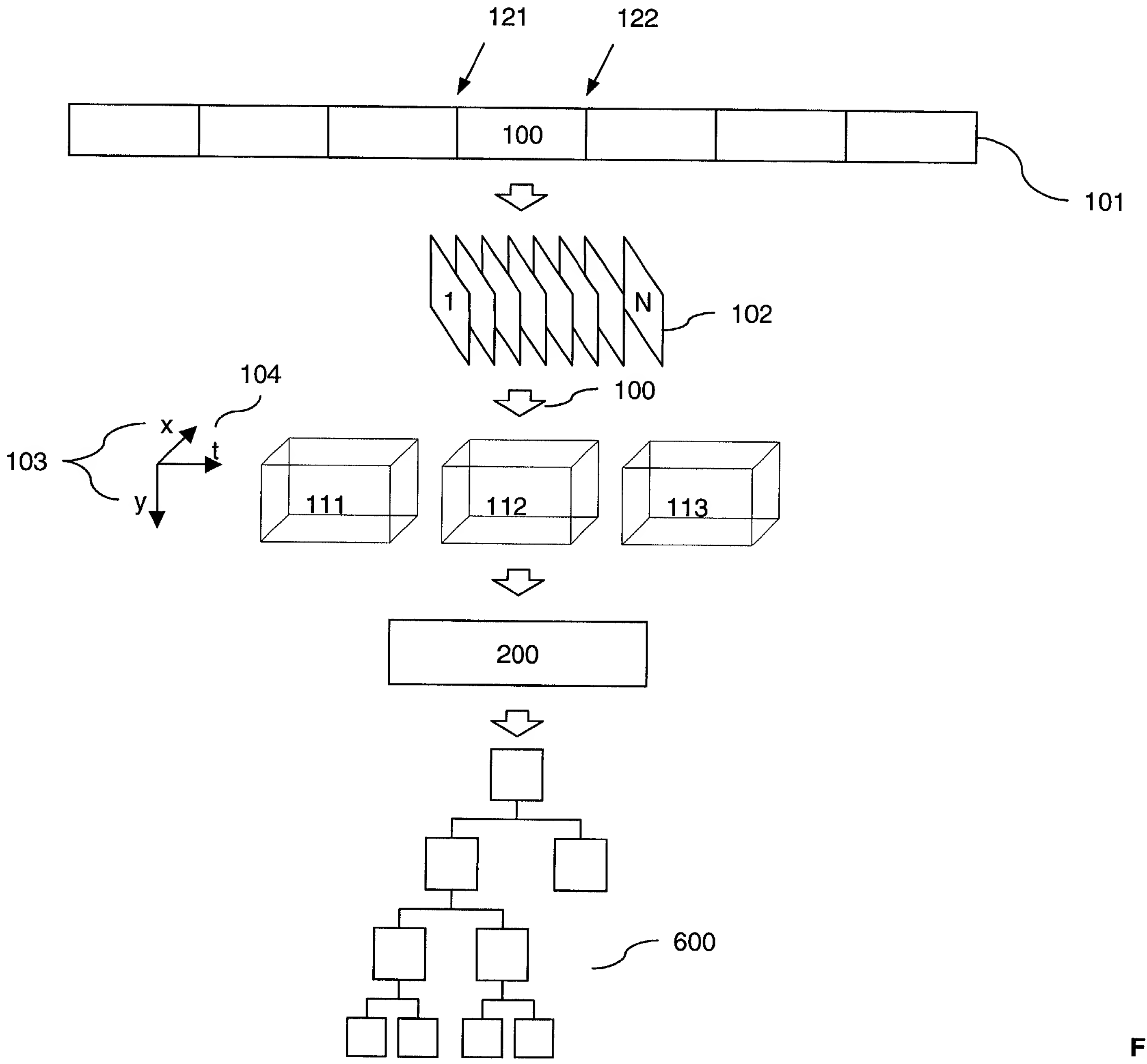


Figure 1

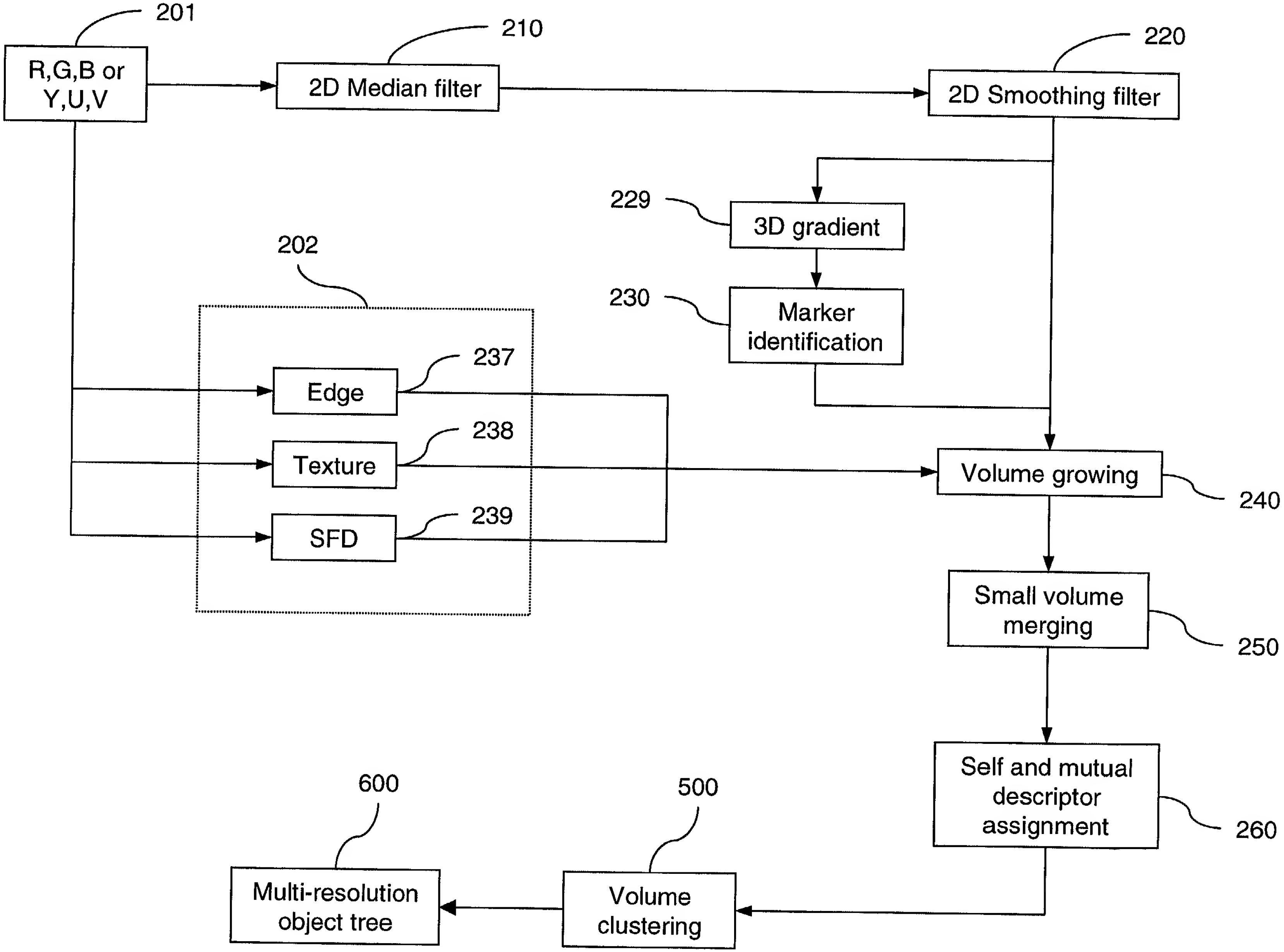
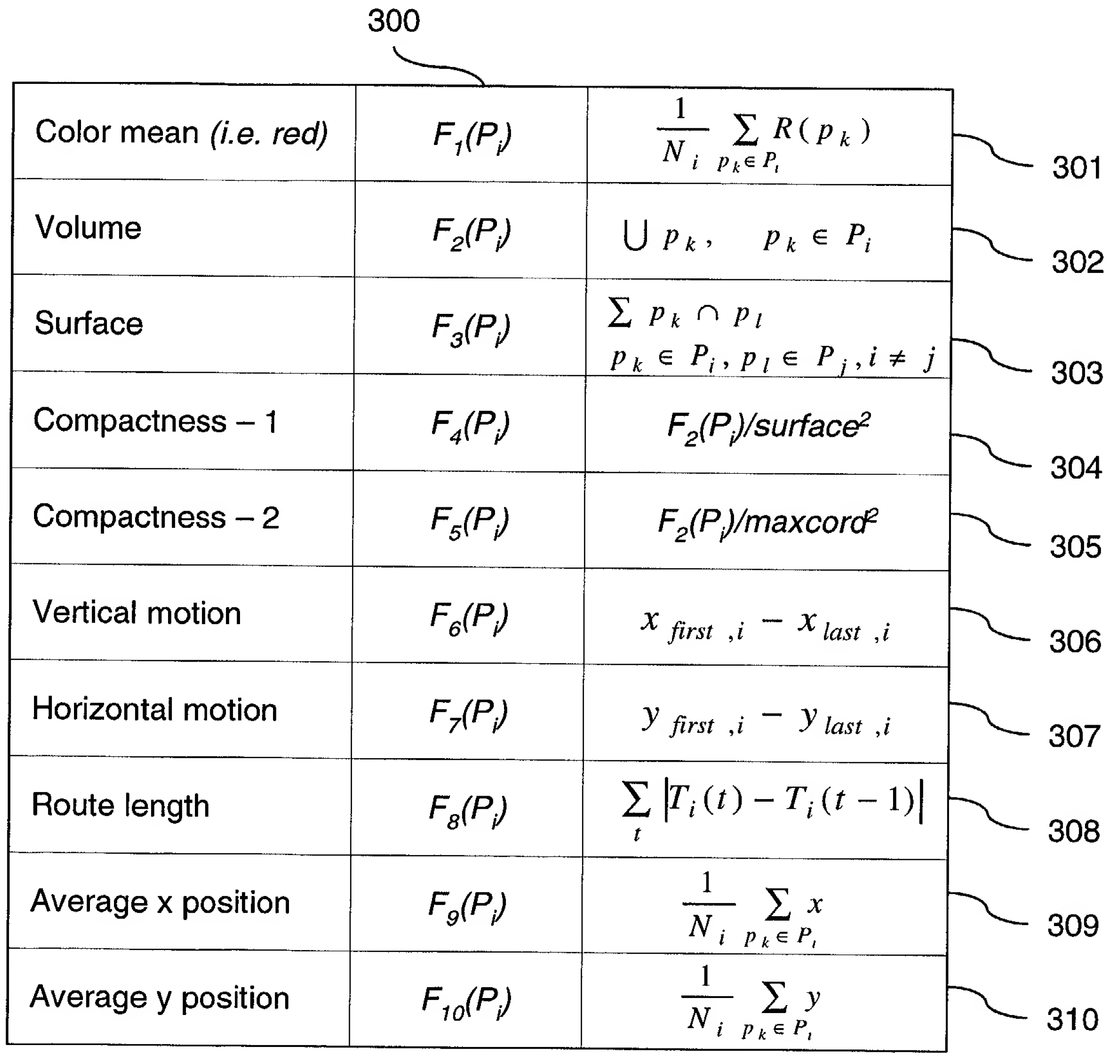
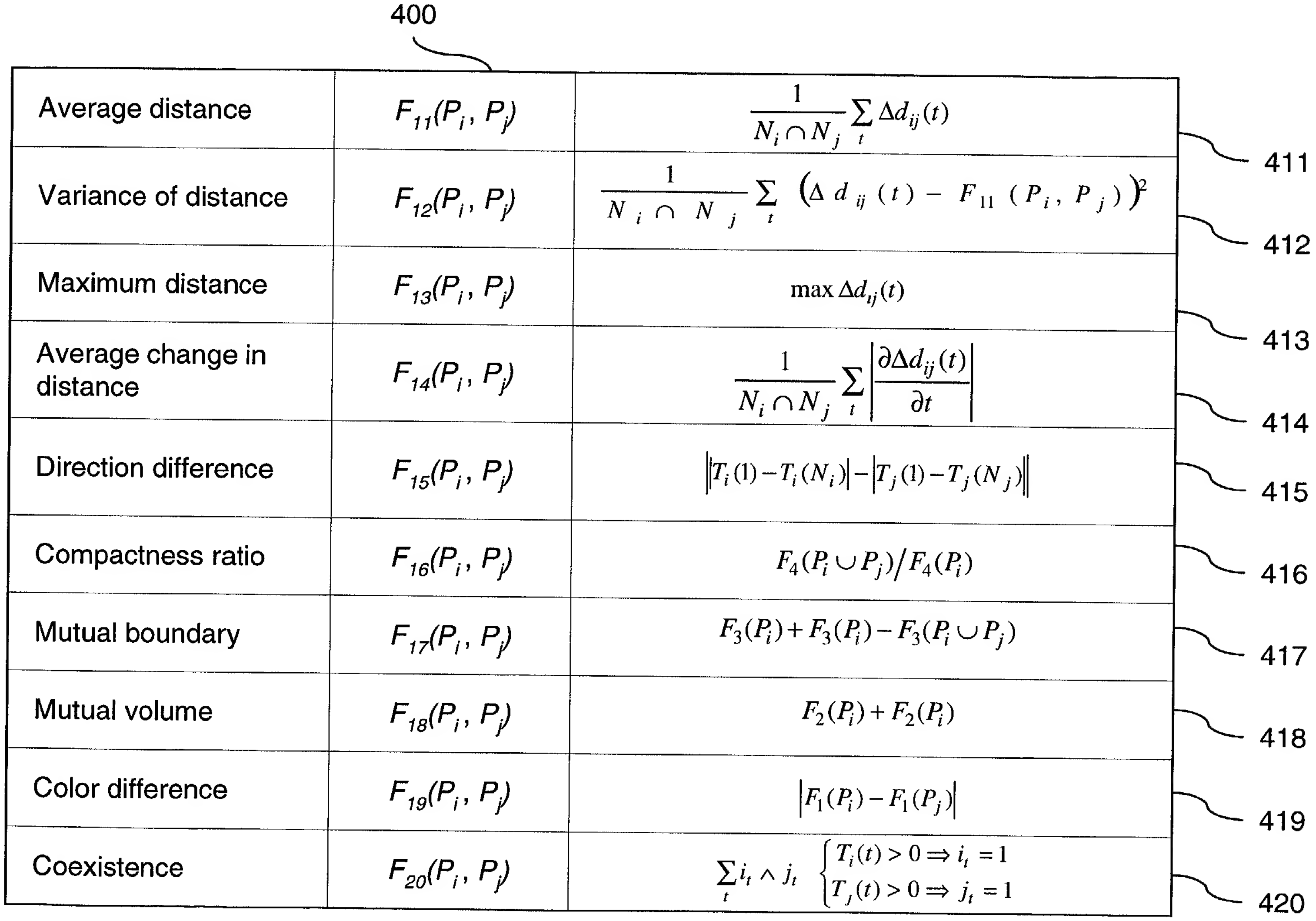

201
R,G,B or Y,U,V
210
2D Median filter
220
2D Smoothing filter
229
3D gradient
230
Marker identification
202
237
Edge
238
Texture
239
SFD
240
Volume growing
250
Small volume merging
260
Self and mutual descriptor assignment
500
Volume clustering
600
Multi-resolution object tree

Figure 2



Color mean *(i.e. red)*	$F_1(P_i)$	$\frac{1}{N_i}\sum_{p_k \in P_i} R(p_k)$
Volume	$F_2(P_i)$	$\bigcup p_k, \quad p_k \in P_i$
Surface	$F_3(P_i)$	$\sum p_k \cap p_l$ $p_k \in P_i, p_l \in P_j, i \neq j$
Compactness – 1	$F_4(P_i)$	$F_2(P_i)/surface^2$
Compactness – 2	$F_5(P_i)$	$F_2(P_i)/maxcord^2$
Vertical motion	$F_6(P_i)$	$x_{first,i} - x_{last,i}$
Horizontal motion	$F_7(P_i)$	$y_{first,i} - y_{last,i}$
Route length	$F_8(P_i)$	$\sum_t \lvert T_i(t) - T_i(t-1)\rvert$
Average x position	$F_9(P_i)$	$\frac{1}{N_i}\sum_{p_k \in P_i} x$
Average y position	$F_{10}(P_i)$	$\frac{1}{N_i}\sum_{p_k \in P_i} y$

Figure 3



Average distance	$F_{11}(P_i, P_j)$	$\frac{1}{N_i \cap N_j} \sum_t \Delta d_{ij}(t)$
Variance of distance	$F_{12}(P_i, P_j)$	$\frac{1}{N_i \cap N_j} \sum_t \left(\Delta d_{ij}(t) - F_{11}(P_i, P_j)\right)^2$
Maximum distance	$F_{13}(P_i, P_j)$	$\max \Delta d_{ij}(t)$
Average change in distance	$F_{14}(P_i, P_j)$	$\frac{1}{N_i \cap N_j} \sum_t \left\lvert \frac{\partial \Delta d_{ij}(t)}{\partial t} \right\rvert$
Direction difference	$F_{15}(P_i, P_j)$	$\left\lVert T_i(1) - T_i(N_i) \rvert - \lvert T_j(1) - T_j(N_j) \right\rVert$
Compactness ratio	$F_{16}(P_i, P_j)$	$F_4(P_i \cup P_j) / F_4(P_i)$
Mutual boundary	$F_{17}(P_i, P_j)$	$F_3(P_i) + F_3(P_i) - F_3(P_i \cup P_j)$
Mutual volume	$F_{18}(P_i, P_j)$	$F_2(P_i) + F_2(P_i)$
Color difference	$F_{19}(P_i, P_j)$	$\lvert F_1(P_i) - F_1(P_j) \rvert$
Coexistence	$F_{20}(P_i, P_j)$	$\sum_t i_t \wedge j_t \quad \begin{cases} T_i(t) > 0 \Rightarrow i_t = 1 \\ T_j(t) > 0 \Rightarrow j_t = 1 \end{cases}$

Figure 4

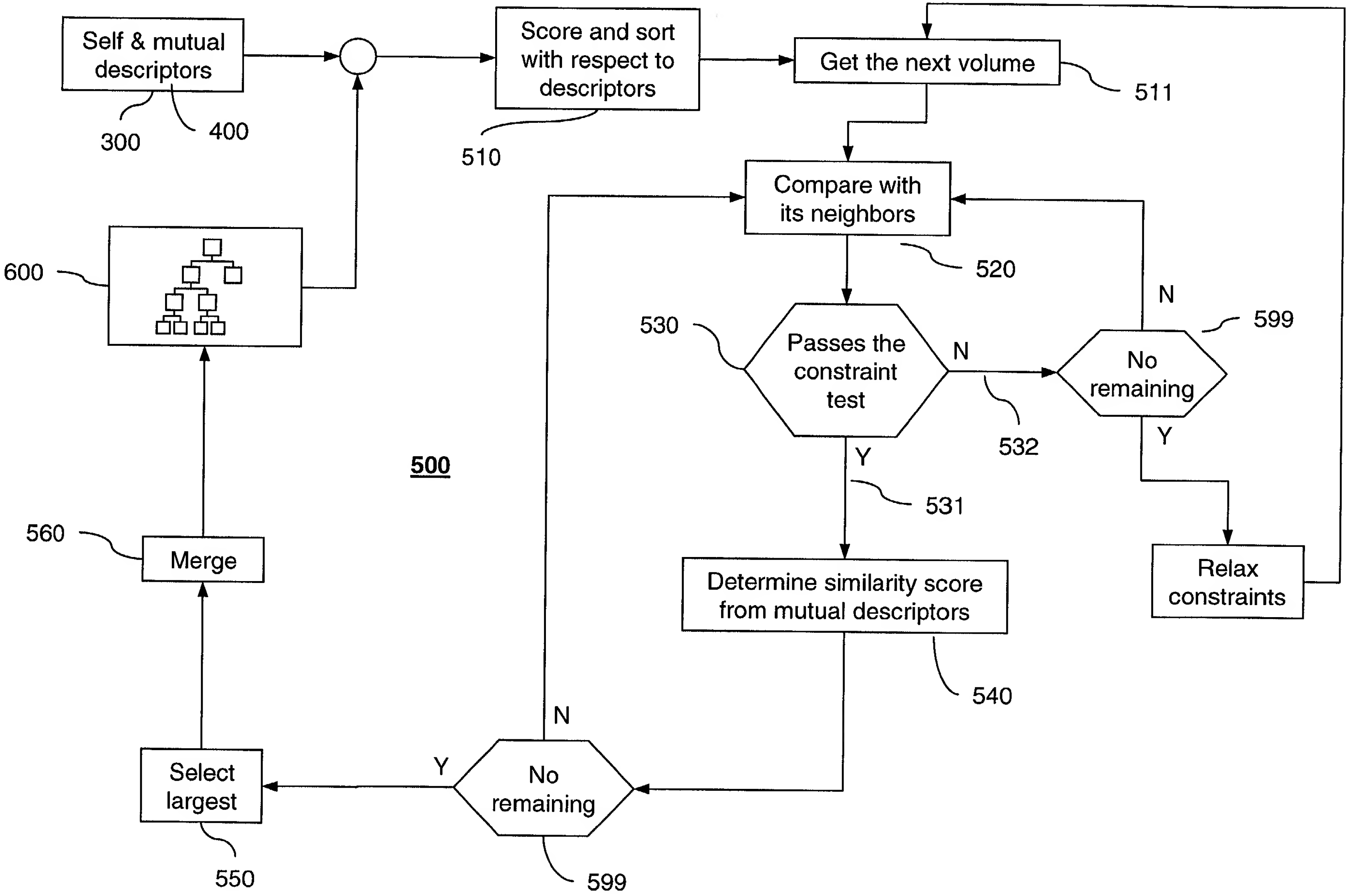

Self & mutual descriptors
300
400
Score and sort with respect to descriptors
510
Get the next volume
511
Compare with its neighbors
520
600
Passes the constraint test
530
N
532
No remaining
599
N
Y
Y
531
500
560
Merge
Determine similarity score from mutual descriptors
540
Relax constraints
N
Y
No remaining
Select largest
550
599

Figure 5

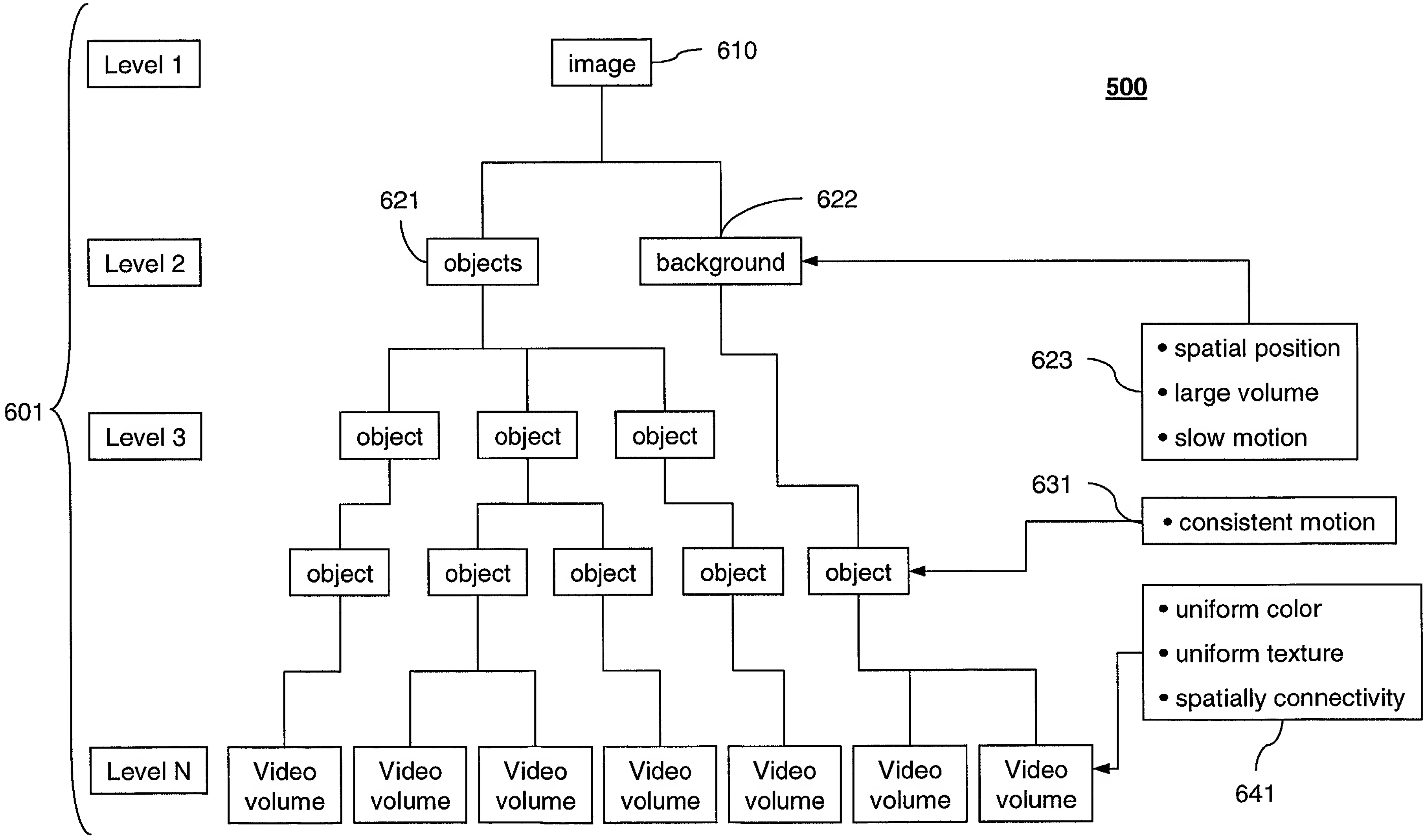

500
Level 1
Level 2
Level 3
Level N
601
image
610
objects
621
background
622
object
object
object
object
object
object
object
object
Video volume
Video volume
Video volume
Video volume
Video volume
Video volume
Video volume
623
• spatial position
• large volume
• slow motion
631
• consistent motion
• uniform color
• uniform texture
• spatially connectivity
641

Figure 6

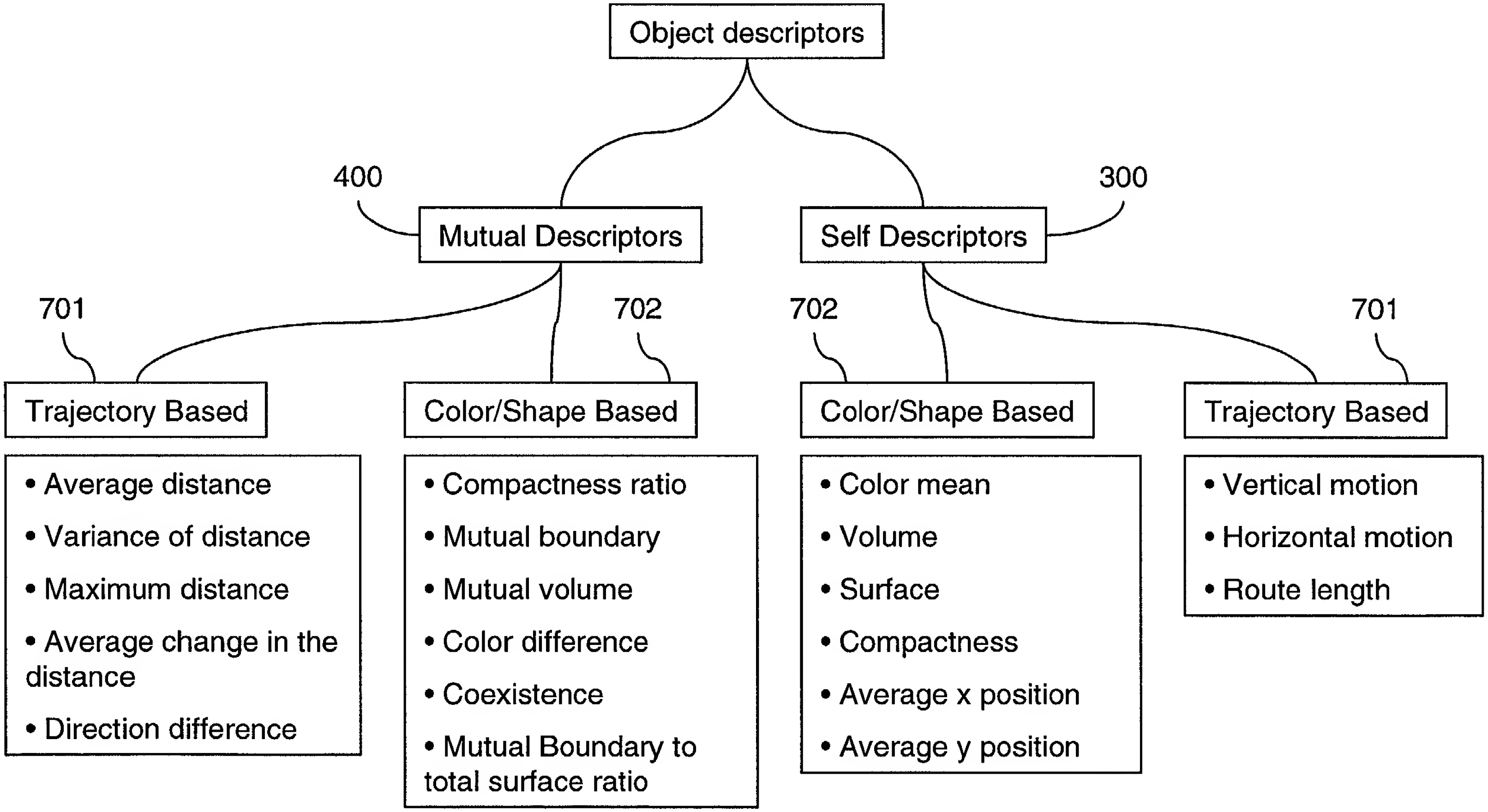

Object descriptors
400
Mutual Descriptors
300
Self Descriptors
701
702
702
701
Trajectory Based
Color/Shape Based
Color/Shape Based
Trajectory Based
• Average distance
• Variance of distance
• Maximum distance
• Average change in the distance
• Direction difference
• Compactness ratio
• Mutual boundary
• Mutual volume
• Color difference
• Coexistence
• Mutual Boundary to total surface ratio
• Color mean
• Volume
• Surface
• Compactness
• Average x position
• Average y position
• Vertical motion
• Horizontal motion
• Route length

Figure 7

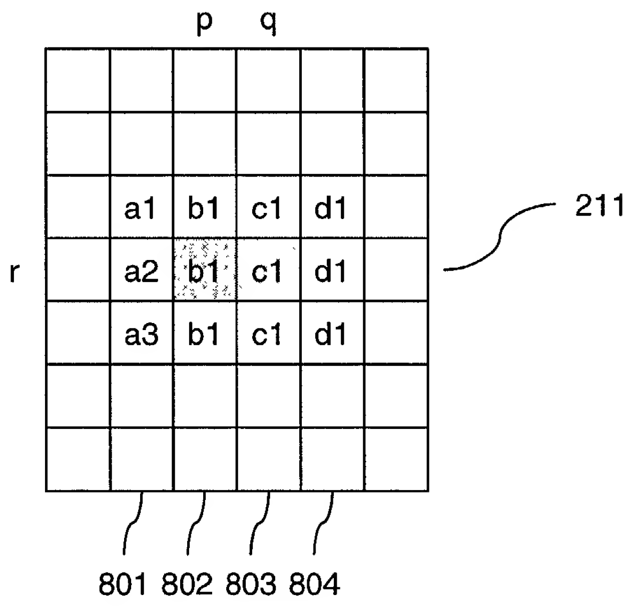
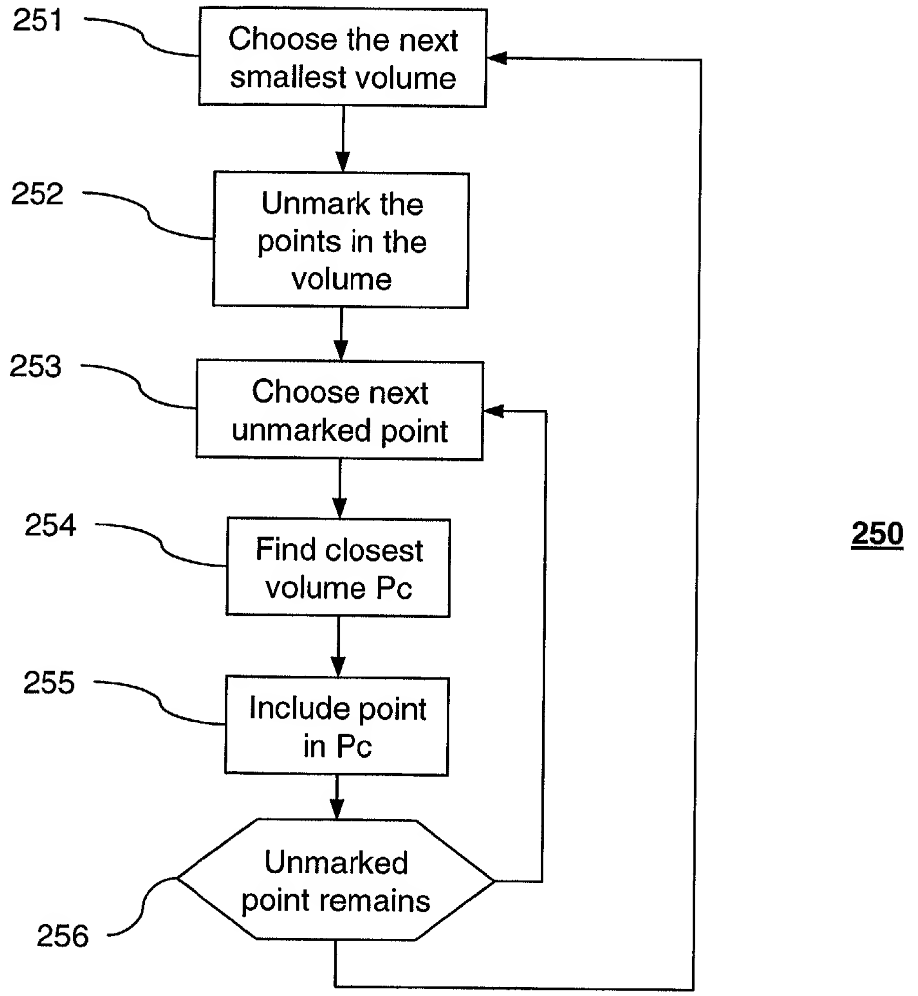


Figure 8



251
Choose the next smallest volume
252
Unmark the points in the volume
253
Choose next unmarked point
254
Find closest volume Pc
255
Include point in Pc
256
Unmarked point remains
250

Figure 9